Global Journal of Advanced Engineering Technologies Volume 7, Issue1- 2018
ISSN (Online): 2277-6370 & ISSN (Print):2394-0921

DESIGN AND FABRICATION OF WIND POWERED VEHICLE

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Abstract: *An electric powered vehicle has a bank of batteries that runs the entire vehicle. This work focuses on charging the batteries of the vehicle on the run. This is done by capturing the wind that acts opposite of a moving car. There is always the flow of wind as long the cars moves with a speed. A wind turbine is mounted on the front of the vehicle to receive wind. The generator produces electricity from the wind and stores them in another battery. The vehicle moves with the pre-charged battery and a voltage sensing circuit is placed on one or more batteries of the vehicle to detect the drop in voltage. In such case the reservoir battery that gets charged through wind switches the position with the low voltage battery and continues to run the vehicle while the other battery gets charged. This process can go on until the vehicle comes to stationary. While one of the limitations of the electric vehicles is their short travel range compared to their excessive charging time. The travel range can be extended by charging the battery on the motion. This paper mainly focuses on the design of the wind powered car and to determine the power required for driving the system.*

Index Terms: *Wind turbine, generator, sustainable energy, battery, electric car.*

I. INTRODUCTION

The use of alternate energies used in automobiles is popular nowadays such as solar powered, hybrid and plug-in hybrid. Electric vehicles are now slowly replacing petroleum vehicles. The pollution caused by the internal combustion vehicles is very high. Here the need for completely sustainable and pollution free energy powered vehicles comes into role. The wind energy is free, sustainable, inexhaustible and abundantly available in the air. Asia is the fastest growing region in terms of wind energy where China being the world's largest wind energy producer with 145,362 MW. A wind turbine is a device that converts kinetic energy of the wind into mechanical energy and into electricity using a generator [3]. Electric cars are becoming popular as an alternate to gasoline vehicles to reduce pollution. But a drawback of electric cars are their shorter range in travel comparatively. The average travel distance on an electric powered vehicle is less than of a gasoline vehicle. The range of electrically-powered vehicles can be increased by charging the batteries while the vehicle is in motion. This can be achieved by capturing air currents and utilising it as power [7].When a vehicle moves there are two types of wind resistance that acts, namely frictional drag and form drag. Frictional drag arises due to viscosity of air and form drag arises due to variation of air pressure in the front and rear side of the vehicle. If a stationary wind turbine is placed near a road, we can absorb energy from it when it rotates due to the air caused by movement of vehicles beside it. If it is possible to capture those wind streams within the vehicle itself then it can be used to recover some of energy that has been used to overcome the form drag of the vehicle. This system uses a wind turbine installed in the chamber in front of a vehicle that rotates and converts the kinetic energy into electrical energy using a generator. The chamber has an opening in its front for receiving air and a rear exit vent. That noise that is caused by the wind turbine is eliminated by sound absorbing materials. This energy is stored in a separate battery that supports vehicle's battery system. This in turn acts as a reservoir which eventually increases the efficiency of the vehicle. The vehicle has to be charged externally like normal electric car though the wind energy supports it later. The main aim of the project is nothing more than conservation of the planet earth which is under serious danger that is caused by various types of pollution mainly by the increased and over ranging vehicles that causes emissions at relatively larger scale.

II. RELATED STUDY

The blade design is calculated and designed using wind and wet software. The technical information regarding the generator and its components are obtained from its manual. The conversion of power from wind to electricity is common worldwide. But the practicality of this is never implemented on vehicles due to various factors like noise, less generation of power from it, size etc. the fact that it can bring a huge change is unavoidable. The wind always acts opposite to a moving vehicle which can be captured continuously. *Leon Boodman, James P. Malone* 1982 , this method provides additional power supply in an electric vehicle. The car has an air scoop that opens when the vehicle moves forward. There is a turbine inside the air scoop that rotates when the vehicle moves and a generator connected to it to generate electricity from the turbine. This in turn will charge the batteries of the vehicle .

V.M.Prajapati, K.H.Thakkar 2013 [1] Growing negative effects of the conventional fuels urged the scientists to develop newer methods as an alternate to conventional fuels due to their pollutions and harmful effects. According to this project the author aimed to produce power from renewable sources like wind. A small turbine is used to produce electricity using drag force of the wind in a moving vehicle. This project promotes the use of wind energy which can be used for various purposes. A table fan is attached to a motor as a wind energy converter. This produces electrical and mechanical energy using wind turbines for utilization of various electrical appliances. This method is suitable for vehicles as it can reduce the fuel consumption of the vehicle. When the wind velocity increases, the overall efficiency of the wind energy converter increases.

Shafiur Rahman, Dr.M.G.Patil 2015 [2] , This project uses a two way hybrid mobile charger. It uses both solar and wind as their energy sources. Solar can be used during day time and while we are still. While the wind energy method can be used while travelling, keeping the fan near the vehicle window panel or somewhere and night time where there is no sunlight. They both have AC charger input option within it. A small computer cooling fan is attached to a dc motor to generate electric current through wind power. This method will bring a great change among the non-conventional energies as they can be widely used.N.S. ***Hanamapure, Ajit B. Bachche 2013 [4]*** According to the research wind energy can be utilised in a moving vehicle. For this purpose small CPU fans having DC motors are mounted on the bumper of the vehicle. This motor when used in reverse generates electricity. This electricity can either be used to charge the vehicle's battery system or can be used for various other electrical systems such as lights etc. Several small fans are used for this purpose. This method boosts the vehicle's fuel efficiency by cutting down the electrical usage from the fuel in an eco-friendly manner. 50W of power could be withdrawn when the car moves with the velocity of 100kmph. With this power any one of the appliances of the vehicle can operated.

Ms.NannooriSwathi & Mr. Prof. J.Nagaraju 2015 [3] this research emphasises the use of wind energy. The wind energy is used to power a wireless robot through RF technology. There are plenty of wind in the atmosphere which is free, eliminates the need to purchase, and no storage required. This project uses a robotic vehicle which has a small wind turbine installed to it. A generator is connected to it which gets charged by the wind and stores in a battery. The battery then powers the robot and its peripherals. A micro controller is used as controlling device. RF communication ranges between 30 KHz to 300 GHz. The proposed device runs on electricity transmitted through wind turbines.

III. METHODOLOGY

The flow chart shown below in figure 1 gives the detail on how the project is carried out. The project is mainly divided into three main parts:

- *Design:* The optimum design is carried out, it is drafted in AutoCAD software for reference and material is selected.
- *Fabrication:* Every part is machined and fabricated according to the dimension after assembly is carried out.
- *Testing:* The model is tested to see if the desired result is obtained and necessary modifications are done on the system.

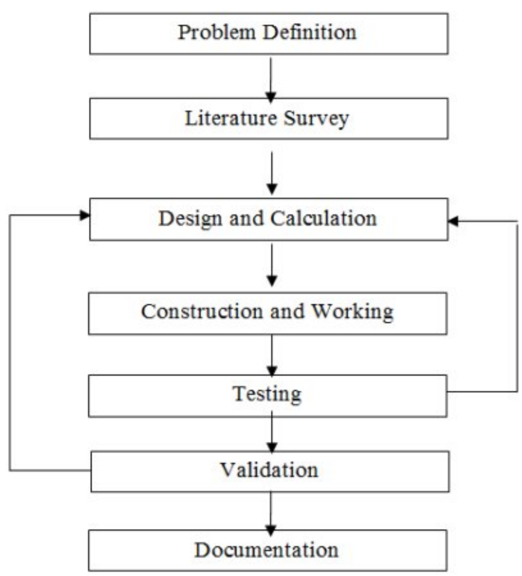

Figure 1: Methodology involved in design and fabrication of Wind Powered Car

The following procedures are followed in the building process:

Selection of blades*:* The main focus is to obtain maximum power with minimum velocity of the turbine and designing the turbine blades according to requirements of the storage system. Also turbine blade should rotate at required RPM to generate electricity.

***Selection of generator**:* it aims to obtain maximum voltage with minimum RPM of the rotor. Above set up uses three phase permanent magnet generator.

***Material for fabricating vehicle**:* The system uses light weight, more strength and durable material. Mild steel is used to build the frame and GI sheet is to cover the system.

***Modeling, drafting & design**:* Modeling of the vehicle is done by CREO and drafting in AutoCAD to obtain an optimum design for maximum efficiency, reliability and comfortable movement of the vehicle.

***Testing**:* Testing of the turbine blade in order to ensure the blades rotates at a required RPM to generate electricity and also to determine the amount of power from the reservoir battery to the main battery.

***Validation**:* Ensuring that the test results coincide with calculated values to ensure successful validation and taking corrective actions and re-doing the design process in-order to achieve the results (Compared with standard).

***Documentation**:* Documentation contains the entire details regarding the project, limitations, cost and estimation, validation that have been overcome from the existing methods, its applications over other similar methods.

Frontal area = πr^2…………….. (1)

Calculating power of the turbine, P=$1/2 C\rho AV^3$…. (2)

Blade angle, $\beta = \tan\left(\frac{2R}{3r\lambda}\right) - \alpha$………………. (3)

Equation (1), (2) and (3) represents the calculations which is involved to obtain front area where blades are positioned, power of the turbine and the blade angle.

IV. DESIGN, CONSTRUCTION& WORKING

Design of *blade:* The turbine blades are made out of PVC pipe which has numerous advantages over other materials such as cost and weight. The wind powered car has a maximum speed limit of 35 kmph therefore the selected material is could withstand a linear velocity of 50 kmph which is sufficient and cost effective for the vehicle. Table 1 shows the material property of PVC. Figure 2 represents the profile of the blade.

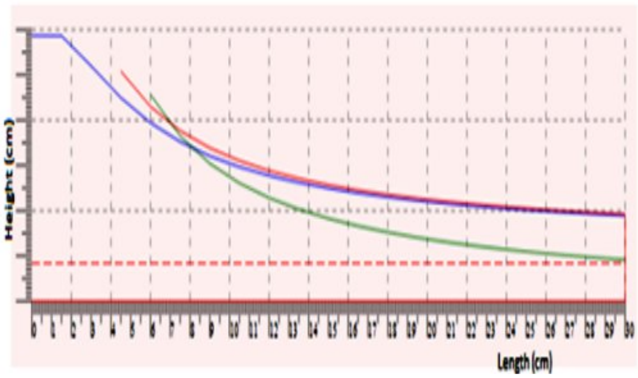

Figure 2: Blade Profile
[Source: www.windandwet.com]

Table 1: material Property of PVC

SL NO.	PROPERTY	VALUE
1	Young's Modulus	3378 MPa
2	Density	1.3 g/cm^2
3	Compressive strength	65 MPa
4	Poisson's Ratio	0.3
5	Ultimate tensile stress	31 MPa

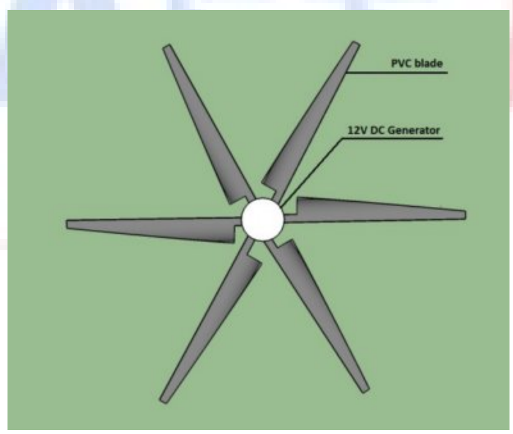

Figure 3: Front view of turbine

The *turbine* used for the power generation is a 12V DC generator which can produce power upto 315W and generate up to 75A of current. Specifications of turbine are shown in table 2.

Table No. 2: Turbine specifications

SL NO.	PARTICULARS	VALUES
1	Hub diameter	140mm
2	Fan diameter	700mm
3	Number of blades	6
4	Blade thickness	3mm
5	Blade length	300mm
6	Blade width	25mm-55mm (taper)
7	Material	PVC

The *chassis* is made of aluminium which has qualities like greater axial load strength, durable, less finishing cost and less weight. The material used for the *frame* of the vehicle's body shown in figure 4 is mild steel. Mild possess qualities like ductility, easily weldable, cost effective and strong. Ten pieces of ¾ inch hollow mild steel pipe of 2 meter each, weighing upto 5kg each are used for the vehicle construction.

Bodywork: Galvanized Iron sheets are used for the body work shown in figure 5. The sheets and cut and bent manually as per the measurements and welded onto the frame. GI sheets of 1mm thickness are used for this vehicle. They do not corrode easily and is cheaper than aluminium but heavier in weight. The welding method used for this vehicle is *spot welding*. This is the basic welding method and is easier to operate even for a beginner as they are less dangerous and do not require any filler metal or flux. As the entire vehicle was manually crafted, spot welding was preferred since the further modification of the vehicle design was easily possible. Spot welding set up is shown in figure 6.

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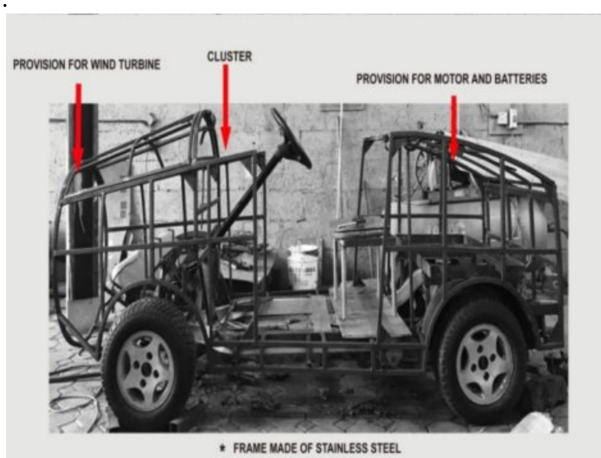

Figure 4: Frame work of the vehicle

Figure 5: Body work of the vehicle

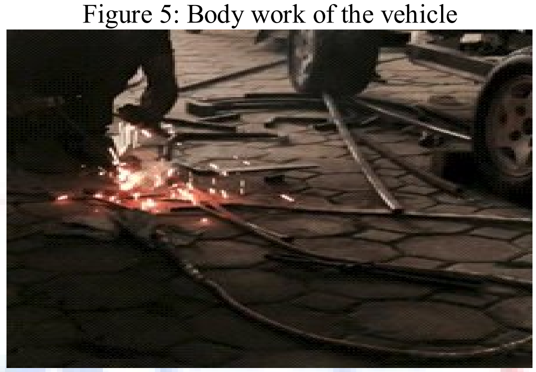

Figure 6: Spot welding process

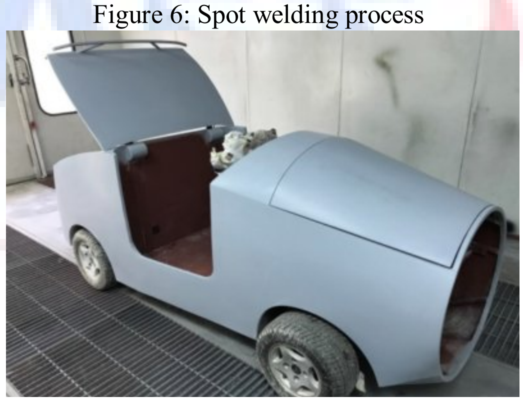

Figure 7 : Primer coat applied after grinding

Figure 8: Painting work of the vehicle

Figure 9: Final Finished Product

Finishing and Painting: The gaps formed after the joining the body sheets are filled using fibre fillers. Steel putty are applied onto the uneven surfaces of the body as well. Grinding process is done later as a finishing work before painting. Grinding is done again after a coat of primer applied and three coats of metallic paint is sprayed on the vehicle. The vehicle is kept in a heat controlled booth for perfect finishing for a day. A final finishing process of polishing is done after the paint has been dried.

WORKING:

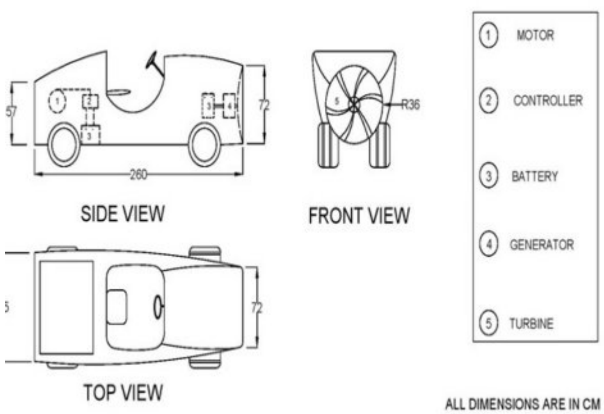

Figure 10: Final draft of the wind powered car

This electric car consists of six lead-acid batteries of 8 volt and 175Ah each connected in series that gives 48 volt. The batteries are connected to the controller which is connected to a 48 volt 2.3 kW DC motor which is again connect to the rear axle of the wheels. The acceleration is electrically controlled by the controller using a pedal. A reservoir battery of the same specification is connected to the vehicle's battery via a switch which can be turned on when the voltage of the vehicle drops below 40 V. This reservoir battery gets charged by the turbine and acts as a backup and boosts the vehicle thus mainting the top speed of the vehicle for a longer time. This reservoir battery also gets recharged by the turbine even when it is in connection.The turbine is connected to a charge controller that charges the battery and maintains the voltage, such that only the battery only gets the charge if the turbine produces sufficient voltage, also cuts the the power transmission to the battery to protect it if the voltage is too high. The vehicle needs to run for at least three hours at top speed in order to recharge the entire batteries with wind energy. In order to keep up that speed the voltage of the batteries should be maintained, thus the reservoir battery helps in regaining the voltage drop. At top speed the turbine rotates at 1500 RPM which generates 75 A of current which recharges the entire battery 3-4 hours.

V. RESULTS AND DISCUSSION

By considering Coefficient of performance, Cp= .40 (For this wind turbine),Velocity of wind, v = 5.5 m/s, Density of air, ρ = 1.225 kg/m^3, Radius of the turbine, r = 0.35 m. Front area and power of the turbine is found to be 0.384 m^2 and 12.77 watts using equation (1) and (2). Similarly by consideringradius of the blade, R = 0.3 m, Angle of attack, α= 4 ,Tip speed ratio, λ= 6 blade angle is found out to be 3.99 degrees it is calculated using equation 3.

The following result shown in table 3 is obtained by testing where the wind car is operated at various speeds .The power generated by the turbine with respect to RPM and linear velocity is determined.

Table No. 3: Generator readings

Linear velocity of the vehicle (km/h)	RPM of the blade	Voltage (v)	Current (A)	Power (W)
13	650	13	0.5	6.5
20	900	15	5	75
25	1200	19	10	190
35	1500	21	75	315

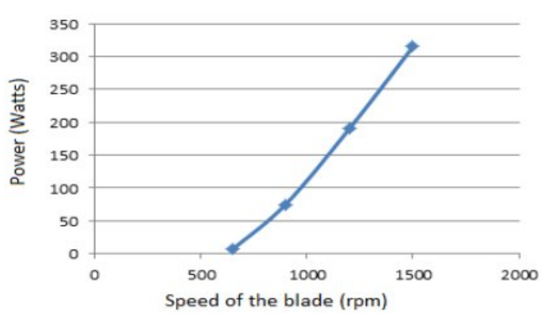

Figure 11: Blade speed vs. Power

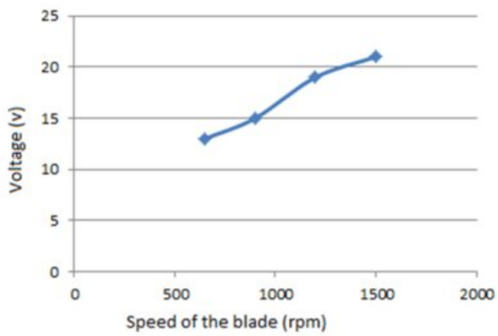

Figure 12: Blade speed vs. Voltage

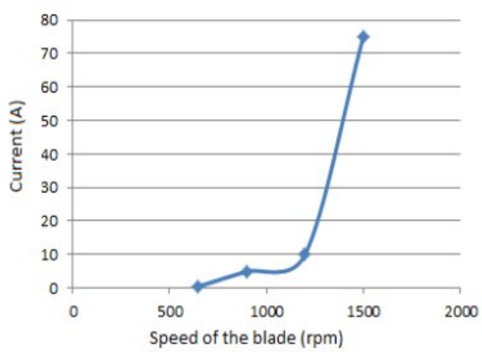

Figure 13: Blade speed vs. Current

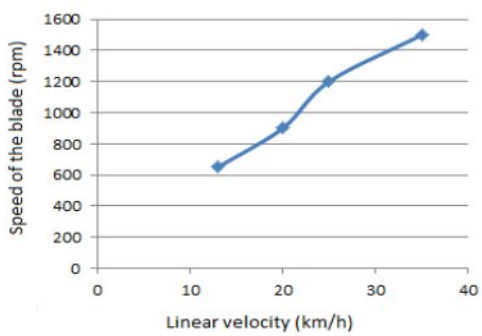

Figure 14: Linear velocity vs. Blade speed

From the figure 11, 12 and 13 it is inferred that as the speed of the blade increases the power, voltage and current generated by the turbine increases. Figure 14 infers that there is an increase in the rpm of the turbine with the rise in the linear velocity.

The wind powered vehicle was tested after its completion. It was tested at various speeds and weather conditions (windy climate). The turbine was able to rotate at a minimum speed of 15kmph and would continue to rotate even when the speed drops. It needs an initial torque for the turbine to start rotating. The power obtained from the turbine varies with the speed of the vehicle. More the RPM of the turbine more the current stores in the battery.

The following were the challenges faced and some of them were able to rectify:

The weight of the vehicle was a problem as the weight of the vehicle and the speed of the vehicle are inversely proportional. There were materials like aluminium which is lighter in weight but was expensive and will increase the cost of the project dramatically. So mild steel and GI sheets were used to build the frame and body of the vehicle. Though the weight reduction didn't come into effect, the strength and durability of the vehicle stood strong. There was a great research on the type of the generator to be used for the turbine. The cheapest among them was a treadmill motor which can be used as a generator (reverse current). But the torque required to turn the shaft of the motor was more as it wouldn't suit the current project. The vehicle requires a generator with less torque so that the turbine can rotate even at slower speeds. Then a windmill generator is used which is highly efficient in capturing energy from the wind. Storing the captured energy into the batteries was a difficult task. Numerous confusions arise at this point. How will the energy obtained will be used to run the vehicle was the question? After thorough research, the wind energy is made to store in a reservoir battery and when the charge of the vehicle drops, the reservoir battery acts as an additional battery pack, with the help of a switch that connects them both.

Selection of material for the turbine blade was chosen as PVC because of numerous factors such as weight, cost, easily mouldable, and availability. PVC could have replaced by other composite material like carbon-fibre since its durability and efficiency is higher, but for this vehicle PVC is sufficient as a blade material because the top speed of the vehicle do not cross the breaking point of the material. Unlike typical wind energy turbine, there is no shaft between the turbine and the generator. The blades are directly attached to the hub of the generator which rotates together. This setup eliminates friction caused by the shaft and saves space. The diameter of the turbine was chosen according to the vehicle's design to obtain maximum aerodynamics and for optimal power generation. The power generation is related to size and number of blades of the turbine. Therefore an optimum design between number of blades and size was necessary. The vehicle could run for 9 hours with full charge of the batteries. The weight of the entire vehicle can be distributed by placing the batteries evenly throughout the vehicle as now the batteries are placed exactly above the rear axle which causes maximum load at the rear of the vehicle. The design of the vehicle is in such a way that the torque required by the turbine to rotate is more than the minimum speed required to rotate the blades on the run. The blades rotate even at the slow speed of 13 kmph of the vehicle generating 0.5 A of current. The dead weight of the vehicle is 450 kg which is technically heavier for a energy generating purpose. This can affect the turbine performance also by resisting its maximum rotation due to the speed limit. With all these results, it was clear that the energy from the atmosphere can be trapped and be used for charging the vehicle itself though the power obtained was less comparing to the various other sustainable energy methods. Unlike solar panels, this method can be used for anytime of the day. The actual result of the power obtained was less comparing to the expected result and the main reason to it was the weight of the vehicle.

VI. CONCLUSION

The increasing number of vehicles is creating a high demand of fossil fuels which are in fact exhausted highly. Creating a wind powered vehicle will serve as an environment friendly which requires no fossil fuel and utilizing the energies from the atmosphere. The wind powered vehicle focuses on utilizing the non-conventional energies that are available freely in the nature. There are several methods of harvesting such energies in our daily lives and this method is just a beginning. The method used for this purpose is a wind turbine that captures and stores the energy in a battery that helps to increase the runtime of the vehicle also helps in charging the vehicle as well. Advantages such as cost effective, eco-friendly and free energy conservation can be added. The current weight of the vehicle is a concern which limits the speed of the vehicle. The vehicle can be used in various fields where the fossil fuel is expensive and highly polluted cities where they struggle in reducing carbon footprint. Future may seem to have electric cars that can charge on the run and wind power method will be one among them.

From the graphs, Speed of the blade vs. Power we can conclude that the power generated from the turbine increases with the increase in the speed of the blade. Speed of the blade vs. Voltage, it shows that the voltage produced by the turbine increases as increase in the speed of the blade. Speed of the blade vs. Current, it shows that the current produced by the turbine increases with the increase in speed of the blade. Linear velocity vs. Speed of the blade, it concludes that the speed of the blade increases with the linear velocity of the vehicle. Some of the merits this vehicle offers like it uses sustainable energy as fuel since it does not pollute the environment, Conservation of energy which is free and abundant and utilising it in the daily lives, Cheap of cost effective compared to other electric cars and Energy can be generated at any time of the day unlike solar vehicles.

FUTURE SCOPE: Changing the overall design of the vehicle to reduce its weight, increasing aerodynamics and redesigning such that more air enters into the chamber of wind turbine. Using substitute material for the turbine blades. Material such as carbon fiber is very light weight, strong and durable even at high speed of the vehicle. Implementing this method in all type of vehicles. This method helps an electric car to recharge it; also this method will be efficient in gasoline cars where the wind energy can be used for various other purposes thus reducing the load on car's stock battery. Addition of solar panel is one of the future scopes thus highly increasing the efficiency of the vehicle. Design of the blade can be altered by changing the profile. This in turn increases the RPM of the blade with the same linear velocity. The vibrations and noise from the turbine can be eliminated by providing noise absorbing boards on the surface of the turbine chamber and dampers to reduce vibration when rotating at higher RPM. Changing the configuration of the turbine from vertical horizontal. This is highly effective because the blades and the air are perpendicular which can rotate it efficiently. But the overall design of the vehicle has to be redesigned. Replacing the existing motor with another of same power consumption but high output. Super capacitors are similar to battery that can store energy quickly but also discharges them too fast. This could be replaced with the batteries for weight reduction and better efficiency. Switching of the reservoir battery to connect it to the main batteries can be made automatic by voltage sensing circuits which can detect voltage drop automatically and activate it. Fluid analysis can be carried out using dimensionless number. Further works includes writing an algorithm using advanced software for commercial purposes.

NOMENCLATURE

C_p – Coefficient of performance
V – Velocity of wind (m/s)
ρ – Density of air (Kg/m^3)
r – Radius of the turbine (m)
R – Blade Radius (m)
α – Angle of attack (degree)
λ – Tip speed ratio
β – Blade angle (degree)

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